Bibliography of Studies Documenting the Impacts of Highway Runoff

Buckler, D. R. and G. E. Granato (1999). Assessing Biological Effects from Highway-Runoff Constituents, U.S. Department of the Interior, U.S. Department of Transportation, USGS.

> Review of the literature indicates (qualitatively) that highway runoff (even from highways with high traffic volume) may not usually be acutely toxic. Tissue analysis and community assessments, however, indicate effects from highway-runoff sediments near discharge points (even from sites near highways with relatively low traffic volumes). At many sites, elevated concentrations of highway-runoff constituents were measured in tissues of species associated with aquatic sediments. Community assessments also indicate decreases in the diversity and productivity of aquatic ecosystems at some sites receiving highway runoff. These results are not definitive, however, and depend on many site-specific criteria that were not sufficiently documented in most of the studies reviewed.

Chen, Y. S., R. C. Viadero, et al. (2009). "Effects of Highway Construction on Stream Water Quality and Macroinvertebrate Condition in a Mid-Atlantic Highlands Watershed, USA." Journal of Environmental Quality **38**: 1672-1682.

> Refining best management practices (BMPs) for future highway construction depends on a comprehensive understanding of environmental impacts from current construction methods. Based on a before-after-control impact (BACI) experimental design, long-term stream monitoring (1997-2006) was conducted at upstream (as control, n = 3) and downstream (as impact, n = 6) sites in the Lost River watershed of the Mid-Atlantic Highlands region, West Virginia. Monitoring data were analyzed to assess impacts of during and after highway construction on 15 water quality parameters and macroinvertebrate condition using the West Virginia stream condition index (WVSCI). Principal components analysis (PCA) identified regional primary water quality variances, and paired t tests and time series analysis detected seven highway construction-impacted water quality parameters which were mainly associated with the second principal component. In particular, impacts on turbidity, total suspended solids, and total iron during construction, impacts on chloride and sulfate during and after construction, and impacts on acidity and nitrate after construction were observed at the downstream sites. The construction had statistically significant impacts on macroinvertebrate index scores (i.e., WVSCI) after construction, but did not change the overall good biological condition. Implementing BMPs that address those construction-impacted water quality parameters can be an effective mitigation strategy for future highway construction in this highlands region.

Gobel, P., C. Dierkes, et al. (2007). "Storm water runoff concentration matrix for urban areas." Journal of Contaminant Hydrology **91**: 26-42.

> The infrastructure (roads, sidewalk, commercial and residential structures) added during the land development and urbanisation process is designed to collect precipitation and convey it out of the watershed, typically in existing surface water channels, such as streams and rivers. The quality of surface water, seepage water and ground water is influenced by pollutants that collect on impervious surfaces and that are carried by urban storm water runoff. Heavy metals, e.g.

lead (Pb), zinc (Zn), copper (Cu), cadmium (Cd), polycyclic aromatic hydrocarbons (PAH), mineral oil hydrocarbons (MOH) and readily soluble salts in runoff, contribute to the degradation of water. An intensive literature search on the distribution and concentration of the surface-dependent runoff water has been compiled. Concentration variations of several pollutants derived from different surfaces have been averaged. More than 300 references providing about 1300 data for different pollutants culminate in a representative concentration matrix consisting of medians and extreme values. This matrix can be applied to long-term valuations and numerical modelling of storm water treatment facilities

Paul, M. J. and J. L. Meyer (2001). "Streams in the urban landscape." Annual Review of Ecology and Systematics **32**: 333-365.

The world's population is concentrated in urban areas. This change in demography has brought landscape transformations that have a number of documented effects on stream ecosystems. The most consistent and pervasive effect is an increase in impervious surface cover within urban catchments, which alters the hydrology and geomorphology of streams. This results in predictable changes in stream habitat. In addition to imperviousness, runoff from urbanized surfaces as well as municipal and industrial discharges result in increased loading of nutrients, metals, pesticides, and other contaminants to streams. These changes result in consistent declines in the richness of algal, invertebrate, and fish communities in urban streams. Although understudied in urban streams, ecosystem processes are also affected by urbanization. Urban streams represent opportunities for ecologists interested in studying disturbance and contributing to more effective landscape management.

Sansalone, J. J., J. M. Koran, et al. (1998). "Physical characteristics of urban roadway solids transported during rain events." Journal of Environmental Engineering-Asce **124**: 427-440.

Urban stormwater runoff from paved surfaces transports a wide gradation of solids ranging in size from smaller than 1 mu m to greater than 10,000 mu m. This study measured physical characteristics of solids transported in lateral pavement sheet flow from a heavily traveled roadway in Cincinnati. Particles smaller than 25 mu m were counted and sized using a light obscuration particle counter. Particles larger than 25 mu m were separated mechanically to generate particle size distributions. Solids in the 2-8 mu m range generated the largest counts and were rapidly washed from the pavement. LPSF rate and duration controlled yield and size of transported solids. Particle transport was mass limited during long duration high intensity events, but dow limited during intermittent low intensity events with high traffic. Particle counts exhibited a first flush from the pavement. Specific surface area generally increased with decreasing particle size, but measured values deviated from the monotonic pattern expected for spherical particles. Particles 425 to 850 mu m in size contributed the greatest total surface area. Results provide guidance for assessment of the impact of urban runoff water quality and for design of in situ treatment strategies.

Spellerberg, I. F. (1998). "Ecological effects of roads and traffic: a literature review." Global Ecology and Biogeography **7**: 317-333.

This survey of the literature on the ecological effects of roads and traffic revealed many articles published over many years in peer reviewed journals. There has also been a growing number of reports on the ecological effects of roads produced by government authorities. Whereas few reports have been published on assessing the ecological impacts, there has been a rapidly growing number of reports on methods for mitigation. Gaps in research include the effects of heavy metal accumulation and the processes and effects resulting from habitat fragmentation. There is a need to assess the effectiveness of underpasses and tunnels and the nature and functioning of buffer zones. A literature database has been assembled and is being updated.

Wheeler, A. P., P. L. Angermeier, et al. (2005). "Impacts of new highways and subsequent landscape urbanization on stream habitat and biota." Reviews in Fisheries Science **13**: 141-164.

New highways are pervasive, pernicious threats to stream ecosystems because of their short- and long-term physical, chemical, and biological impacts. Unfortunately, standard environmental impact statements (EISs) and environmental assessments (EAs)focus narrowly on the initial direct impacts of construction and ignore other long-term indirect impacts. More thorough consideration of highway impacts, and, ultimately, better land use decisions may be facilitated by conceptualizing highway development in three stages: initial highway construction, highway presence, and eventual landscape urbanization. Highway construction is characterized by localized physical disturbances, which generally subside through time. In contrast, highway presence and landscape urbanization are characterized by physical and chemical impacts that are temporally persistent. Although the impacts of highway presence and landscape urbanization are of similar natures, the impacts are of a greater magnitude and more widespread in the urbanization phase. Our review reveals that the landscape urbanization stage is clearly the greatest threat to stream habitat and biota, as stream ecosystems are sensitive to even low levels (< 10%) of watershed urban development. Although highway construction is ongoing, pervasive, and has severe biological consequences, we found few published investigations of its impacts on Streams. Researchers know little about the occurrence, loading rates, and biotic responses to specific contaminants in highway runoff. Also needed is a detailed understanding of how highway crossings, especially culverts, affect fish populations via constraints on movement and how highway networks alter natural regimes (e.g., streamflow, temperature). Urbanization research topics that may yield especially useful results include a) the relative importance and biological effects of specific components of urban development-e.g., commercial or residential, b) the scenarios under which impacts are reversible; and c) the efficacy of mitigation measures-e.g., stormwater retention or treatment and forested buffers.

Wu, J. S., C. J. Allan, et al. (1998). "Characterization and pollutant loading estimation for highway runoff." Journal of Environmental Engineering-Asce **124**: 584-592.

Three highway segments typical of urban, semiurban, and rural settings in the Piedmont region of North Carolina were monitored to characterize the respective runoff constituent concentrations and pollutant discharge or export loadings. Runoff from the impervious bridge deck (Site I) carried total suspended solids (TSSs) concentrations and loadings that are relatively higher than typical urban highways, whereas nitrogen and phosphorus loadings are similar to agricultural runoff Site II included a pervious roadside shoulder with traffic volume equal to that of Site I. Site III was a nonurban highway having lower traffic counts and imperviousness due to the presence of a roadside median. The existing roadside shoulder and median appeared to attain at lease 10-20% hydrologic attenuation of peak runoff discharges, more than 60% reduction of event mean concentration of TSSs, and attenuation of the first-flush concentrations

for most pollutant constituents. Bulk precipitation data collected at the bridge deck site indicated that 20% of TSS loadings, 70-90% of nitrogen loadings, and 10-50% of other constituent exports from the roadway corridors might have originated from atmospheric deposition during dry and wet weather conditions. The long-term highway pollutant loadings have been derived to provide a basis for comparing highway runoff with other categories of nonpoint sources (NPSs).

Additional Articles

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